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Method for hot granulating metal-containing substance particles, such as sponge iron, metallurgical dusts, metallurgical residues, etc.

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(56) Related Art
US 4769211
US 403559

Abstract

The present invention relates to a method for hot compacting metal-containing substance particles, such as sponge iron, metallurgical dusts, metallurgical residues, etc. Such a method is to simplify the further processing also of fine-grained and/or pyrophoric substances within a metallurgical plant or steel works. The method comprises the following steps:

supplying the hot substance particles to a roller press;

producing a continuous strip plate by the roller press; and

producing a granulate by crushing the strip plate.

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AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

STANDARD PATENT

Applicant:

MASCHINENFABRIK KOPPERN GMBH & CO. KG

Invention Title:

METHOD FOR HOT GRANULATING METAL-CONTAINING SUBSTANCE PARTICLES, SUCH AS SPONGE IRON, METALLURGICAL DUSTS, METALLURGICAL RESIDUES, ETC.

The following statement is a full description of this invention, including the best method of performing it known to us:

Method for hot granulating metal-containing substance particles, such as sponge iron, metallurgical dusts, metallurgical residues, etc.

The present invention relates to a method for hot granulating metal-containing substance particles, such as sponge iron, metallurgical dusts, metallurgical residues, etc.

To be able to subject, in particular, metallurgical residues or directly reduced sponge iron to further processing (melt), there are a number of methods in the prior art. Most of the time, these substances are present in the form of powder to fine powder and can thus only be handled in a very disadvantageous way for many intended applications. Moreover, they are often pyrophoric, and there are precise rules regarding their storage and transportation. For instance, in order to ship sponge iron, said iron must be pressed into briquettes of a predetermined density and surface passivation. The briquetting systems comprise two counter-currently working briquetting rollers, each comprising molding pockets on their surfaces. The briquetting rollers are thus coupled with one another such that there are always two molding pockets impinging on one another while a remaining residual web between the briquetting pockets is pressed to a very strong degree, which in turn results in an almost automatic separation of the briquettes after these have left the briquetting rollers. It is only due to the sufficient compaction and reduction of the pore volume and the pore surface and the passivation of the surface of the briquettes that the risk of fire, in particular during storage and shipment, is minimized. This method has above all the disadvantage that briquetting rollers are very complicated to produce and that they are subject to extreme wear, in particular in the area of the webs. Moreover, it should be taken into account that a specific amount of the substances is immediately processed further either directly or after being temporarily stored in the works for a short period of time, and that there is essentially no longer storage or shipment.

It is now the object of the present invention to provide a method for hot compacting metal-containing substance particles, such as sponge iron, metallurgical dusts, metallurgical residues, etc., which can be performed in an ~~easier way and leads to less wear on the compacting machines used.~~

To this end the method comprises the following steps:

feeding the hot substance particles to a roller press wherein the substance particles pass through the roller press at an elevated temperature ranging from 450°C to 950°C;

producing a continuous strip plate by the roller press;

producing a granulate of different granular sizes by crushing the strip plate, wherein the density of the granulate is < 5g/cm^3.

With this method, a continuous strip of said substance particles is primarily produced by exploiting the ductility of the material at elevated temperatures and the resulting binding mechanisms of the metal particles (in particular iron particles). The strip can extend over the whole width of the roller press and has preferably a thickness which permits compaction to a sufficient degree also in the interior of the plate. So far it has always been customary to briquette such substances. Upon a direct further processing in metallurgical plants or steel works, a uniform lump size, passivated surface, or high minimum density is not needed. The powder-like material must just be made lumpy such that it is e.g. introduced into a melt during further processing and can drop in the melt. This has been detected by the inventor who now suggests the method using simple roller presses. Such roller presses may be exposed to much greater wear than is the case with briquetting presses. Of prime importance is here an adequate feed when the desired density is produced. The service lives are increased considerably by the simple roller geometry. For instance, if sponge iron is to be processed on site, it is granulated in response to the amount needed and is supplied to a further process. Storage and shipment are thus not necessary, that is why the corresponding rules need not be heeded.

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It should be noted that the continuous strip plate is produced on account of the properties of metal-containing substance particles without the addition of binders. This method differs from granulating methods for products without said adhesion characteristics. Furthermore, other granulating methods are carried out in a cold state. For an excellent development of the binding characteristics, the substance particles run through the roller press at elevated temperatures. To obtain a sufficient ductility as well as adequate binding characteristics of the metal-containing particles, these characteristics are typically obtained at temperatures preferably ranging from 600°C to 700°C. For instance, compacting temperatures for sponge iron from the reduction of fine ore may amount to 600-720°C, in the case of directly reduced ore or also metallurgical dusts from the rotary hearth to 700-900°C, and in the case of metallurgical residues from a rotary tubular furnace to 500-600°C.

Furthermore, the density of the granulate, preferably ranges from $\geq 3g/cm^3$ to $< 5g/cm^3$. In particular in the case of granulate of sponge iron or metallurgical dusts, densities between $3g/cm^3$ and $5g/cm^3$ are desired, depending on the quality of the feed material. Therefore, the granulate has most of the time a density smaller than that of similar materials in briquetting methods. In exceptional cases the granulate may also be produced with an increased density, e.g. $< 6g/cm^3$ or $< 7g/cm^3$. In some cases, especially with hot sponge iron, the density may be less than $4.5 g/cm^3$.

Preferably, the strip plate can be produced with a roller nip ranging from > 5 mm to 40 mm, preferably 10 mm to 30 mm. An essential difference between compaction for the formation of granulate and briquetting is that in the case of compaction for granulate formation no pronounced webs are produced (wear). Thus a larger nip or roller distance is used. The desired lump sizes of a compacting operation for granulate production depend on the way how the material is further processed. When LD dust is processed, a particle size of e.g. > 10 mm is desired for the converter.

Although in a basic version compaction with smooth rollers would also be possible, the roller presses can produce a profiling on both main sides of the strip plate for improving the feed characteristics of the roller presses. Said profiling, however, must only be so large that the desired improved feed is achieved. This, however, also helps to produce predetermined breaking points which reduce the force application for producing the granulate by crushing the strip plate.

In contrast to briquetting in which the mold pockets are to impinge on each other substantially in an accurately fitting way, a variant for improved feed behavior and for producing desired predetermined breaking points provides for profiles disposed on both main sides and having an identical shape and pitch, but an axial and radial offset relative to one another. Despite the profiling this results in a more uniform compaction. Different profiles can also be obtained by an inclined arrangement relative to the roller axes.

Advantageously, the strip plate can be crushed into granulate by shattering the strip plate into an irregular granular size. The method primarily aims at producing particles of a predetermined density. Based on steel production and the introduction of granulated sponge iron into the steel melt, this means that the particles must have such a density that they drop into the melt. The size of the granular particles must of course reach a minimum amount, but the size of formerly used briquettes is definitely not needed. Advantageously, a whole range of different granular sizes can be produced at once and used in the same subsequent method.

The strip plate can be crushed into granular material with an irregular granular size by shattering the strip plate and subsequently supplying the broken pieces or fragments to an impact crusher. The energy needed for granulation is thereby divided, and the individual systems can work more efficiently and are no longer subjected to a very high load.

To achieve a certain pre-compaction of the substance particles or an increase in throughput by generating a pre-pressure, the hot substance particles may be supplied by means of a feed screw means. Large gas inclusions during supply are thereby avoided to a considerable extent and a uniform plate strip is achieved.

Furthermore, the granular size can be made uniform within a predetermined range. Screen systems as well as post-granulation or recycling into the previous crushing process are here particularly suited, so that only granulate of a predetermined size range is produced.

Embodiments of the present invention shall now be explained in more detail with reference to drawings, in which:

Fig. 1 is a schematic illustration showing a roller press including two crusher rollers;

Fig. 2 is a schematic illustration showing a roller press with another embodiment of a crusher;

Fig. 3 is a schematic illustration showing a roller press with screw type feed and a first variant of a crusher;

Fig. 4 is a schematic illustration of a roller press with screw type feed and a second variant of a crusher;

Fig. 5a shows a first variant of a crusher in a schematic front view;

Fig. 5b shows the crusher of Fig. 5a in a top view;

Fig. 6a shows a second variant of a crusher in a schematic front view;

Fig. 6b shows the crusher of Fig. 6a in a top view;

Fig. 7 shows a third variant of a crusher in a schematic front view;

Fig. 8a is a schematic illustration of a first embodiment of a roller press in a partial view;

Fig. 8b shows a press roller of the roller press of Fig. 8a in a schematic top view;

Fig. 9a is a schematic illustration of a second embodiment of a roller press in a partial view;

Fig. 9b shows a press roller of the roller press of Fig. 9a in a schematic top view;

Fig. 10 shows a first variant of a flowsheet for producing granulate;

Fig. 11 shows a second variant of a flowsheet of an apparatus for producing granulate; and

Fig. 12 shows a third variant of a flowsheet of an apparatus for producing granulate.

The method to be described with reference to the figures, as well as the apparatus used therefor, are suited for processing metal-containing substance particles. These are e.g. metallurgical residues or sponge iron having metallic binding properties and showing a plastic behavior at elevated temperatures. For the sake of simplification, sponge iron will only be discussed as the material in the following. Said material is extremely pyrophoric, so that specific rules, regarding in particular storage and shipment, must normally be complied with.

The roller press 1 as is schematically shown in Fig. 1 comprises two counter-currently driven press rollers 2 forming a press nip 4 thereinbetween. The press nip 4 is substantially the same over the whole length. The sponge iron particles 5 are fed via a gravity feeder 6 to the roller nip 4. They are supplied in hot form; in particular, the sponge iron is pressed at an elevated temperature which ensures a certain ductility and releases binding mechanisms of the substance particles. A strip plate 7 is thereby produced, which extends substantially over the whole length of the press rollers 2 and 3. Thanks to the ductile properties of the sponge iron particles 5, these are "welded" to one another without the addition of binders. The roller nip 4 is normally larger than 5 mm, preferably larger than 10 mm. In many cases use is made of a roller nip ranging from 10 to 30 mm. The temperature of the supplied sponge iron particles 5 is preferably 600-720°C. In dependence upon the material to be compacted, hot compaction is carried out in the range of 450-900°C. To be also mentioned as examples: directly reduced iron or also metallurgical dusts from the rotary hearth 700-900°C, and metallurgical residues from a rotary tubular furnace 500-600°C.

Subsequently, the strip plate 7 is supplied to a crusher 8. According to Fig. 1, the crusher 8 comprises two counter-currently driven crusher rollers 9 and 10 that are circumferentially provided with a suitable crusher toothing 11. In the example of Fig. 1, said crusher rollers 9 and 10 directly produce the sponge iron granulate 12 or a pre-product thereof to be crushed once again. Compaction by the roller press 1 must take place such that after production of the granulate 12 lumpy material is present with a density sufficient for the granulate to be able to drop in a steel melt. Sponge iron in powder form is devoid of such a property. Furthermore, sponge iron in powder form is optionally sucked at a great amount into a dedusting means and causes agglomeration as well as a reduced gas flow.

The embodiments of Figs. 8a, 8b and 9a, 9b are stated as examples of the roller press 1.

Figs. 8a and 8b show press rollers 2 and 3 which are provided on their outer surface with a profile in the form of pockets 13 and 13', respectively. Said pockets 13 and 13', respectively, do not show the size as is known for briquetting rollers. Furthermore, an increased distance is needed between the rollers 2, 3 for producing the desired plate strip 7. The press rollers 2 and 3 are substantially of an identical design. However, they are coupled with one another such that the pockets 13, 13' are offset relative to one another. Hence, a web 14 between two pockets 13' in the roller nip 4 coincides with the center of a counter pocket 13. The webs 15 between two pockets 13 coincide again with the center of the pockets 13' of the press rollers 3 in the roller nip 4. The plate strip 7 is thereby provided with a wave shape when viewed in cross section. The thickness is thus essentially the same almost everywhere, the wave valleys 16 also serving as predetermined breaking points for further comminution. A counter impression of the roller profile is thus created on the front main side 17 and the rear main side 18. The fact that the pockets 13 and 13', respectively, are offset relative to one another on the surface of the rollers 2, 3, in surrounding ring rows, results in a strip plate thickness that is as uniform as possible despite profiling. The pockets 13 are offset both circumferentially and axially.

A further possibility of designing the press rollers 2, 3 consists according to the embodiment of Figs. 9a, 9b in that the profile webs 19 and 20, respectively, are applied to the outer circumference. These can e.g. extend in inclined fashion, as shown in Fig. 9b, the webs passing from the center into a counter inclination, resulting in the formation of a kind of arrow. The two press rollers 2,3, in turn, are made substantially identical, but their profile webs 19, 20 are offset relative to one another during rotation of the rollers such that the profile webs of the one press roller 3 engage into the spaces between the profile webs 19 of the other press roller 2, and vice versa. This also results in the formation of a kind of wave profile, which depends on the shape of the profile webs 19, 20. The profile webs 19, 20 may e.g. be applied by welding. As for the design of the

press roller surfaces, the most different materials are suited. Possible are also collars of powder-metallurgical materials. Furthermore, use may also be made of interengaging V-shaped webs which are arranged in opposite direction for producing predetermined breaking points (webs intersect in the roller nip).

In the embodiment according to Fig. 1, the crusher 8 shown in more detail in Figs. 5a and 5b is used. Said crusher 8 comprises two counter-currently rotating crusher rollers 9 and 10, each being provided with a toothing 11. The toothing 11 of the crusher roller 9 consists of three parallel-arranged tooth rims 21. A gap is respectively arranged between said rims. The crusher roller 10 cooperating therewith comprises four tooth rims 22 which are designed in a way similar to tooth rims 21. The tooth rims are offset such that they engage into spaces between the tooth rims 21, so that the two crusher toothings 11 are overlapping. When the strip plate 7 is supplied from above, the crusher 8 ensures the comminution into a granulate or pre-granulate. The number of tooth rims or tooth crests depends, in the final analysis, on the width of the strip plate 7 and the desired size of the granulate.

According to Figs. 6a and 6b, the crusher 8 may also be designed as a crusher roller 23 which works against a fixed stop 24. The crusher roller comprises four tooth rims 25 which cooperate with five teeth 26 of the fixed stop 24 designed as a slide. The crusher roller 23 rotates clockwise against teeth 26. Due to the fact that teeth 26 are offset relative to the tooth rims 25, they are overlapping, resulting in a suitable comminution.

This is e.g. the crusher 8, as is schematically shown in Fig. 2.

Further embodiments will be described with reference to Figs. 3 and 4. Only the differences with respect to the preceding embodiments shall be discussed in the main. That is why identical reference numerals refer to the same or similar components of the preceding embodiments. Reference is made to the above description.

The main difference of the embodiment according to Fig. 3 with respect to Fig. 1 lies in the use of a screw feeder 27. Sponge iron particles 5 are supplied in the hot state via the filling nozzle 28 of the screw feeder 27. There is a certain pre-compaction by the screw 29, so that sponge iron particles 5 are supplied into the roller nip 4 in a very uniform and uninterrupted manner.

An apparatus similar to Fig. 2 is shown in Fig. 4. However, this apparatus also uses a gravity feeder 27. Said feeder extends over the whole effective feed length of the press rollers 2 and 3.

A further embodiment of a crushing apparatus is shown in Fig. 7. Said apparatus 30 is arranged downstream of a pre-crushing device. For instance, a crusher according to Figs. 5 and 6 could be arranged upstream thereof. These could then be adjusted such that they pre-crush the material to a granular size that is not final yet. The pre-broken pieces 12' are then supplied to a centrifugal roller 31 in a chute 32 which comprises a toothed or knobbed lining 33. The pre-broken pieces 12' are thereby flung against the one side of the chute 32 that is designed as an impact plate arrangement 34. This results in a repeated comminution of the material to the final granulate 12. The centrifugal roller 32 rotates clockwise, so that the pieces impinge on the impact plates 34. For reasons of wear the impact plates 34 are given a corresponding stable design.

Various schematic procedural sequences for producing a sponge iron granulate are illustrated in the following with reference to Figs. 10 to 12. For reasons of simplification schematic illustrations of the individual units are chosen. In the units as such the designs described in the preceding embodiments and prior-art designs may be resorted to.

The sponge iron particles 5 are supplied in the embodiment according to Fig. 10 via a gravity feeder 6. A screw feeder could here be used as well. In the roller press 1, a strip plate 7 is produced that is introduced into a crusher 8. In

the instant case the crusher 8 is the crusher according to Fig. 2. However, the other crushing or shattering devices described therein might also be used.

The pre-granulate 12' is supplied to a screen means 35, and granulate below a specific screen size is directly discharged as the final product 12. Pre-product 12' is fed over a specific screen size to a secondary crusher, i.e. a crushing device 30 according to Fig. 7. The final granulate that is then discharged is supplied to the final product 12. A repeated control of the final material arriving from the crushing device 30 is not made.

In the embodiment according to Fig. 11, hot sponge iron particles 5 are again supplied via a gravity feeder 6. Other feeder forms are also admissible. The strip plate 7 is formed in the roller press 1, and subsequent comminution is performed in the crusher 8. The resulting pre-material 12' is fed into a screen device 35, and the final product below a specific screen size, the granulate 12, is discharged therefrom. Pre-material 12', which is above said screen grain size, is fed through the crushing device 30 and is again supplied into the flow of material above the screen device 35. Thus a repeated control takes place through the screen device 35, and only iron sponge granulate 12 below a specific grain size is discharged.

According to the embodiment of Fig. 12, the hot sponge iron particles are supplied via a gravity feeder 6. Other variants of supply may here also be chosen. The hot sponge iron is formed into a strip plate 7 in the roller press 1. Subsequently, it is shattered in the crusher 8. Like in the other embodiments of Figs. 10 and 11, the most different crushing devices may here be used. The pre-material 12' discharged from the crusher 8 is introduced into a screen device 36. Said screen device 36 comprises a two-stage screen, the final product, the sponge iron granulate 12, being discharged between the two screen stages 37 and 38. Pre-material 12', which has a size larger than the screen size of stage 37, is fed through a crushing device 30 and supplied in crushed form to the final product 12. Pre-material 12' which falls through both

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screen stages, i.e. also through the second screen stage 38, is discharged as a fine amount 39 and mixed again with the sponge iron particles 5 above the gravity feeder 6. It is thereby largely ensured that the final product 12 is not above and also not below a certain granulate size range.

All methods can be combined with one another, so that e.g. in the embodiment shown in Fig. 12, like in Fig. 11, the flow from the crushing device 30 is mixed again above the screen device 36 with the pre-material 12'.

The above-described variants of the method can be used for producing granulate for recycling residues into the metallurgical circuit (melt). By contrast, sponge iron from the direct reduction of ores is used as raw material for steel production and introduced into a melt for this purpose. Hence, the method according to the invention is in principle suited for metallurgical recycling methods and also for preparation methods for the use of a raw material.

For the purposes of this specification it will be clearly understood that the word "comprising" means "including but not limited to", and that the word "comprises" has a corresponding meaning.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for hot compacting metal-containing substance particles, such as but not limited to sponge iron, metallurgical dusts, or metallurgical residues for immediate further processing either directly or after being temporarily stored in the works for a short period of time, comprising the following steps:

supplying the hot substance particles to a roller press, wherein the substance particles pass through the roller press at an elevated temperature ranging from 450°C to 900°C;

producing a continuous strip plate by the roller press ; and

producing a granulate of different granular sizes by crushing the strip plate, wherein the density of the granulate is < 5g/cm^3.

2. The method according to claim 1, **characterized in** that the substance particles pass through the roller press at an elevated temperature ranging from 600°C to 700°C.

3. The method according to claim 1 /or 2, **characterized in** that the density of the granulate is $\geq$ 3g/cm^3 to < 5g/cm^3.

4. The method according to any one of claims 1 to 3, **characterized in** that the strip plate (7) is produced with a roller nip ranging from > 5 mm to 40 mm.

5. The method according to claim 4, **characterized in** that the strip plate is produced with a roller nip ranging from 10 to 30 mm.

6. The method according to any one of claims 1 to 5, **characterized in** that the roller press produces a profile on both main sides of the strip plate.

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7. The method according to claim 6, **characterized in** that the profiles on both main sides have the same shape and pitch, but are axially offset relative to one another in the longitudinal direction of the strip plate.

8. The method according to claim 7, **characterized in** that the strip plate is crushed into granulate of an irregular granular size by shattering the strip plate and by subsequently supplying the broken pieces to an impact crusher.

9. The method according to any one of the preceding claims, characterized in that the hot substance particles are supplied by means of a feed screw device.

10. The method according to any one of the preceding claims, **characterized in** that the granular size is made uniform to obtain a predetermined size range.

11. A method for hot compacting metal-containing substance particles substantially as hereinbefore described with reference to the accompanying figures.

Dated this 15th day of June 2004
MASCHINENFABRIK KOPPERN GMBH & CO. KG
By their Patent Attorneys
GRIFFITH HACK
Fellows Institute of Patent and
Trade Mark Attorneys of Australia

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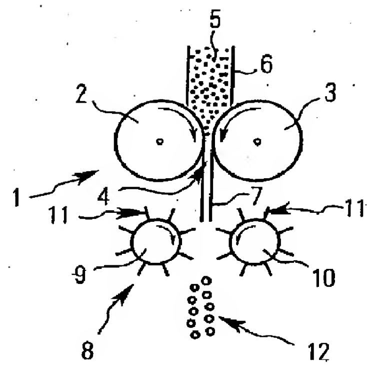

FIG.1

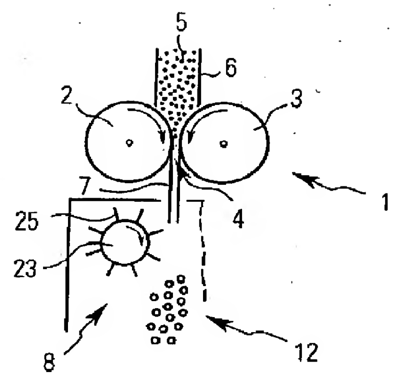

FIG.2

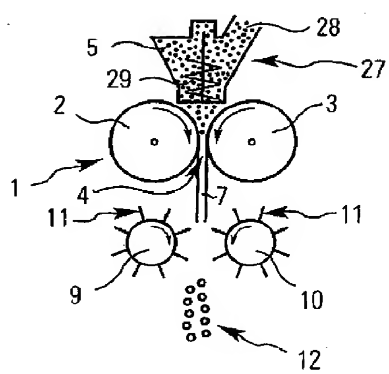

FIG.3

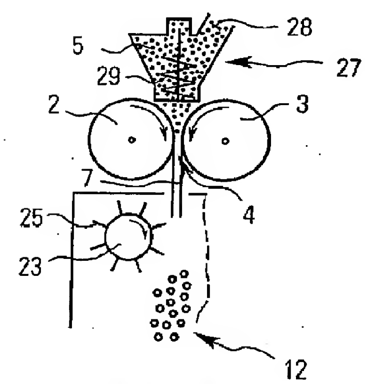

FIG.4

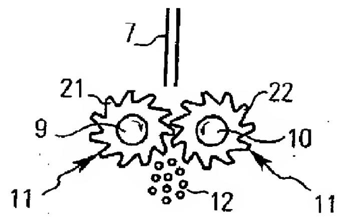

FIG.5a

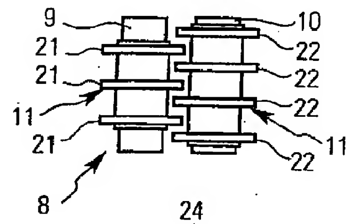

FIG.5b

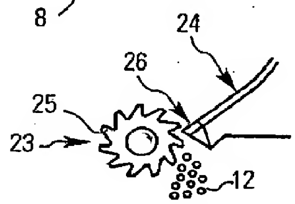

FIG.6a

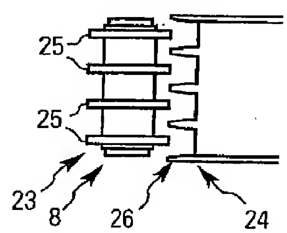

FIG.6b

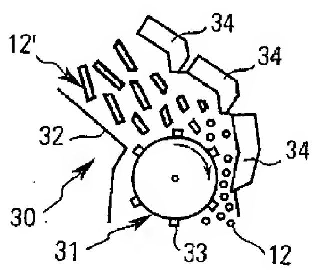

FIG.7

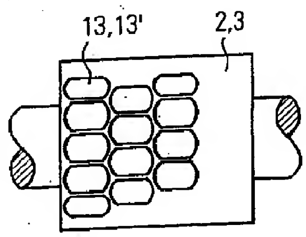

FIG.8b

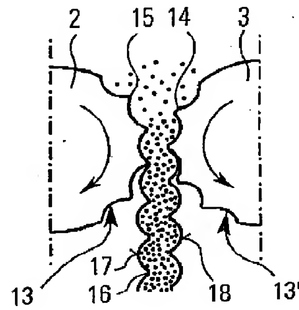

FIG.8a

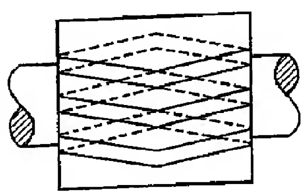

FIG.9b

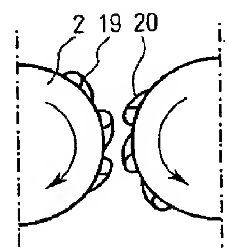

FIG.9a

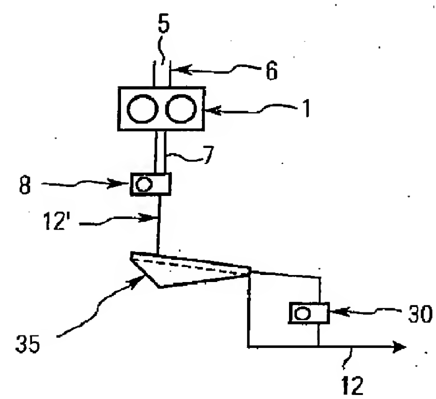

FIG.10

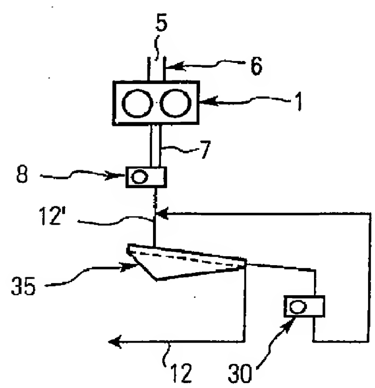

FIG.11

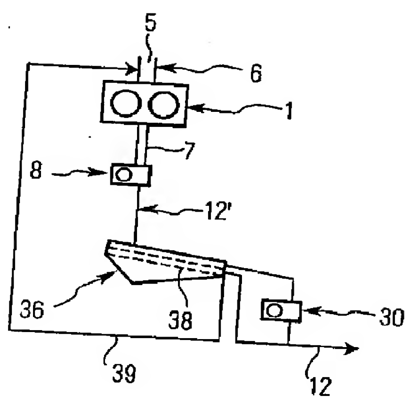

FIG.12